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A Study of the Rosaria Group of the Genus *Diarsia* (Lepidoptera: Phalaenidae) with Special Reference to the Structure of the Male Genitalia¹

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A recent study of that complex of the genus *Diarsia* which at present is found in collections under the name *rosaria* Grt. has convinced me that at least two species, easily separable on the basis of maculation and colouring, have gone under this name. One of these, the true *rosaria*, is confined to the more northerly portions of the California coast. The other species ranges from Alaska south through British Columbia into the Pacific Northwest of the United States, and from the coast of British Columbia east through the northern coniferous forest zone to the coast of Labrador. The latter species is divisible on the basis of well defined genitalic differences into a subspecies inhabiting the Cordilleran region and a subspecies confined to the northern coniferous forest.

To Wm. Bauer, Petaluma, Calif.; Wm. Cook, Walla Walla, Wash.; C. W. Farstad, Dominion Entomological Laboratory, Lethbridge, Alta.; H. McDonald, Dominion Entomological Laboratory, Saskatoon, Sask.; Jas. McDunnough, American Museum of Natural History; Jno. Sperry, Riverside, Calif.; and E. S. Ross, California Academy of Sciences, I am indebted for the loan of material, and to Ken. Bowman, Edmonton, Alta., for the donation of specimens.

DESCRIPTIONS OF SPECIES AND SUBSPECIES

Diarsia rosaria (Grt.)

Head and abdomen buff. Palpi dark-brown laterally, pale mesally. Thorax varying from mahogany to buff-brown. Commonly a sprinkling of grey scales on head and thorax. Patagia often with paler scales at apices but without prominent white collar.

Primaries orange-brown; narrow in proportion to length. A few specimens with rosy flush on primaries. Cubital and anal veins outlined by dark-brown scales throughout their lengths and all other veins so outlined from the t.p. lines to their termini. T.a. and t.p. lines subparallel, usually double. T.a. line sinuate and bowed outward; t.p. line bowed outward, angling sharply inward at costa. Subterminal line pale and somewhat sinuate. Median line of darker-brown scales not invariably present. Subterminal space sometimes paler than rest of wing. Terminal space dark, usually purplish-brown. Claviform absent or indicated only as a faint outline of darker scales. Reniform and orbicular yellow, outlined by dark-brown scales and slightly darkened by admixture of brown scales. Yellow of orbicular and reniform obscured in those specimens with rosy flush on wings. Anterior margin of reniform usually definite; posterior margin usually poorly defined. Usually a median shade of dark-brown scales between reniform and orbicular. Usually a patch of dark scales on costa toward apex, in some specimens forming a definite subapical triangle. Some specimens with a few grey scales on costal margin.

Secondaries buff-grey, darkening toward margins. Discal spot and median line of each hind wing almost always present.

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Both fore- and hind-wings outlined by solid dark-brown line. Fringe of each wing rosy, with a sprinkling of brown scales.

I have examined a Hy. Edwards specimen loaned to me by Dr. McDunnough with a label affixed bearing the number 139. According to the original description this is one of the two specimens from which Grote's description was drawn. The type locality is presumably San Francisco.

On the basis of material studied, *rosaria* is confined to the more northerly portions of the California coast. Specimens have been examined from Mendo-

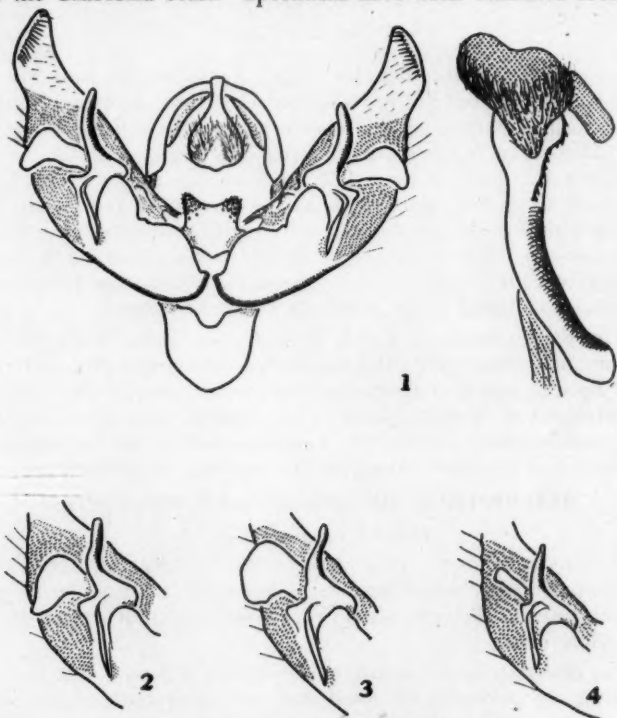


PLATE I

1. External male genitalia of *Diarsia rosaria* Grt. Inverness, Calif.
2. Portion of left valve of *Diarsia pseudorosaria pseudorosaria* Hdwk. (Holotype) showing harpe and ampulla. Head of Pine Creek, Calgary, Alta.
3. Portion of left valve of *Diarsia pseudorosaria pseudorosaria* Hdwk., Vancouver, B.C.
4. Portion of left valve of *Diarsia pseudorosaria freemani* Hdwk. (Paratype) Hopedale, Labrador.

cino, Pt. Arena, Healdsburg, Inverness, San Francisco, Half Moon Bay, and Carmel, as well as several specimens labelled merely Mendocino Co. The material examined was taken between September 8 and July 12. The male genitalia of a specimen of *rosaria* from Inverness are illustrated in Plate I.

On the basis of characters of the male genitalia individual specimens of *rosaria* are in many cases indistinguishable from the species that follows. Maculation and colouring, however, readily separate the two.

Diarsia pseudorosaria sp. nov.

This species has long gone under the name *rosaria* but, although closely related, it is obviously distinct. The differences in the two are easy to see in a

series of both species. *Pseudorosaria* has a much greater range of variability in maculation and colouring than *rosaria*. However, the narrow wings of *rosaria*, the orange ground colour, the yellow of the orbicular and the reniform, the darkening of the veins to the margin of the wing, and the solid marginal line should serve to distinguish that species from *pseudorosaria*.

In the limited series of female genitalia studied, no differences could be found to separate the two species. Differences in male genitalia are discussed in a subsequent section.

Constant differences in two structures of the male genitalia warrant the division of *pseudorosaria* into two geographic races. One is confined to the Cordilleran region, whereas the other inhabits that portion of the northern coniferous forest region extending from the eastern foothills of the Rockies to Labrador.

Diarsia pseudorosaria pseudorosaria *ssp. nov.*

Palpi dark-brown laterally, pale buff-grey anterodorsally. Primaries and thorax ranging from deep chocolate-brown through various shades of brown and red to buff. Apices of patagia often crested with a collar of white scales. Primaries usually considerably broader in comparison with their length than those of *rosaria*. Veins often outlined by dark scales for a short distance distal to the t.p. line but seldom to their termini. Cubital and anal veins only rarely outlined by dark scales proximal to the t.p. line. T.p. and t.a. lines more irregular and crenulate than those of *rosaria*; in a few cases lines obscured. Claviform usually evident as a patch of buff scales. Reniform and orbicular varying from fawn to grey but not approaching the yellow of the spots of *rosaria* in any of the specimens I have seen. Spots usually less definitely emarginated than those of *rosaria*, being often open both anteriorly and posteriorly. Centres of spots usually dark. Many species with considerable suffusion of grey scales at costal margin. Dark outer marginal line of fore wing usually broken at the veins rather than solid as in *rosaria*; marginal scales with ground colour of fore wing. Secondaries similar to those of *rosaria*.

The holotype conforms to the general description above in most respects. The primaries are a bright reddish-brown. The cubital and anal veins are weakly outlined by grey and dark-brown scales proximal to the t.p. line. The reniform is closed anteriorly and bounded posteriorly by the cubital vein. The claviform is very poorly expressed. There is only a suggestion of a median line on the hind wing.

The allotype is deeper in colour, being almost chocolate-brown. The claviform of the primaries and the median line of the secondaries are much more evident than those of the holotype.

Holotype—♂ Head of Pine Creek, Calgary, Alta., June 23, 1896 (F. H. Wolley-Dod). Number 5822 in the Canadian National Collection, Ottawa, Canada.

Allotype—♀ Head of Pine Creek, June 16, 1914 (F. H. Wolley-Dod).

Paratypes—13 males, 9 females, Head of Pine Creek, from June 1 to June 15 (Wolley-Dod).

One paratype has been deposited in the collection of the American Museum of Natural History; the remainder of the type material is in the Canadian National Collection.

The male genitalia of *p. pseudorosaria* are illustrated in Plate I. The subspecies has the same type of elongate harpe and enlarged ampulla as *rosaria*.

The nominate race of *pseudorosaria* ranges from Alaska (Palmer) south, following the Cordilleran system through British Columbia into Washington

(Puyallup), Oregon (Gresham), Idaho (Wallace), and eastern California (Sierra Co., Nevada Co., and Mono Co.). It evidently does not extend into the coastal area of California occupied by *rosaria*. In British Columbia the subspecies extends from Vancouver Island to the eastern foothills of the Rockies.

A few specimens at hand establish the presence of *p. pseudorosaria* at Lethbridge, Alta., and in the Cypress Hills of southwestern Saskatchewan. The population in the latter locality is probably a relict one, whereas the Lethbridge population may represent an extension of the main Cordilleran body that has spread down the valleys of the tributaries of the South Saskatchewan River.

The adult *p. pseudorosaria* flies during spring and summer. One specimen from Vancouver Island was taken as early as the end of April.

I have but one record of the larval habits of the group. A Lethbridge specimen was reared from a "brown larva" feeding on cabbage.

Diarsia pseudorosaria freemani sp. nov.

The only reliable difference between *p. pseudorosaria* and *p. freemani* is to be found in the male genitalia. The ampulla is short and slender in *p. freemani*, being only one-third as large as in *p. pseudorosaria*. The harpe is short and basally broad in *p. freemani*, differing considerably from the long, slender harpe of the nominate subspecies. (Plate I, Fig. 4).

In colour and maculation the two subspecies are very similar, but *p. freemani* is usually smaller and darker. The holotype of *p. freemani* is like that of *p. pseudorosaria*, differing mainly in its smaller size, the somewhat blunter primaries, the poorly expressed median line of the primaries, and the lighter secondaries. The allotype is much darker than the holotype, the median area of the primaries being of a purplish shade.

Holotype—♂ Hopedale, Labr., July 26, 1935 (W. W. Perrett). Number 5823 in the Canadian National Collection, Ottawa, Canada.

Allotype—♀ Hopedale, July 22, 1933 (W. W. Perrett).

Paratypes—8 males, 3 females, Hopedale, from July 21 to August 19 (W. W. Perrett).

One paratype has been deposited in the collection of the American Museum of Natural History and the remainder of the type material is in the Canadian National Collection.

Freemani inhabits the northern coniferous forest region. It apparently ranges from the eastern foothills of the Rocky Mountains to the coast of Labrador. Specimens have been studied from Edmonton, Alta.; Last Mountain Lake, Sask.; Hymers, Ont.; and Hopedale, Labr. In the West the subspecies occurs in the adult stage throughout July, but in the East it flies somewhat later, as may be seen from the data for the type material.

I take great pleasure in naming this northern race after my friend and associate, Dr. T. N. Freeman, who takes such an active interest in northern Lepidoptera and arctic insects in general.

GEOGRAPHIC VARIATION IN THE MALE GENITALIA

In the *rosaria* group there is great variability in the size and shape of different processes of the male genitalia such as the uncus, the juxta, and the valves. However, two of the structures of the male genitalia, the harpe and the ampulla, show not only intra-populational but also inter-populational differences. The inter-populational variation has a geographic correlation. To summarize the differences in the ampulla and the harpe between various geographical populations, two factors have been employed. It was noted early in the course of the study that in western populations the ampulla is both longer and broader than in eastern populations. To indicate the relative size of the ampulla, a factor

has been derived by multiplying the length of this structure by its greatest width and dividing this product by the product of the length of the valve and the greatest width of the valve. The latter step was employed to offset any difference in the size of the ampulla due merely to differences in absolute size of the genitalia. For convenience in working with these factors the dividend was multiplied by ten. This factor, which indicates the size of the ampulla, is termed Y in the following discussion.

Similarly it was noted that as the harpe becomes shorter its base becomes broader. A factor for this structure has been derived by dividing its length by the width of its base. The slimness of the harpe is indicated by the factor X.

Thus:—

$$X = \frac{\text{length of harpe}}{\text{width of base of harpe}}$$

$$Y = \frac{\text{length of ampulla} \times \text{width of ampulla}}{\text{length of valve} \times \text{width of valve}} \times 10$$

The values of X and Y for the individual variants are listed in Table I. The means and standard deviations of X and Y for the various geographic groups are listed in Table II, and the *t* values for these groups are listed in Table III.

In considering Table III, it may be said, in approximation, that where *t* does not attain a value of 2, the difference between the means of the samples is not significant and the two samples probably represent the same integral population. Where *t* exceeds a value of 2 but does not attain a value of 3 (approximating the 5 per cent level of significance) the difference between the means of populations is significant, and where *t* exceeds a value of 3 (approximating the 1 per cent level) the difference is highly significant.

Since the *t* values for both X and Y for the Gresham, Oreg., and coastal British Columbia samples are very small, these samples may be assumed to represent the same continuous, interbreeding population. They are so designated on the chart in Plate II. The latter sample has a greater variability since it represents a number of localities, whereas the former represents but one.



PLATE III

1. *Diarsia rosaria* Grt. Cotype.
2. *Diarsia pseudorosaria pseudorosaria* Hdwk. Holotype.
3. *Diarsia pseudorosaria freemani* Hdwk. Holotype.

TABLE I

THE VALUES OF X (SLENDERNESS OF HARPE) AND OF Y (SIZE OF AMPULLA) FOR INDIVIDUAL SPECIMENS OF THE ROSARIA-PSEUDOROSARIA GROUP FROM DIFFERENT GEOGRAPHIC REGIONS. THE VALUE OF Y FOR ANY INDIVIDUAL IS LISTED IMMEDIATELY BELOW THE VALUE OF X FOR THAT INDIVIDUAL.

A. <i>Diarsia rosaria</i> Grt.		north coastal California	
Salinas, Calif.	X: 2.62 Y: .65	Half Moon Bay, Calif.	X: 2.56, 2.73 Y: .61, .79
Inverness, Calif.	X: 2.95, 2.50, 2.75, 2.29, 2.44, 3.10, 2.68, 2.73 Y: .73, .65, .66, .71, .87, .76, .69, .69		
Mendocino, Calif.	X: 2.60 Y: .83	Pt. Arena, Calif.	X: 2.58 Y: .77
B. <i>Diarsia pseudorosaria pseudorosaria</i> Hdwk.		Gresham, Oreg.	
Gresham, Oreg.	X: 2.17, 2.14, 1.87, 2.36, 2.44, 2.20, 2.34, 1.84, 2.28, 2.20 Y: 1.10, .94, .99, 1.04, 1.02, .95, 1.00, .87, 1.06, 1.04		
coastal British Columbia			
Cowichan Bay, B.C.	X: 2.59 Y: 1.11	Ucluelet, B.C.	X: 2.00 Y: 1.24
Duncan, B.C.	X: 2.72, 2.03, 2.06, 1.96, 2.46, 2.56 Y: 1.08, .97, .86, .69, .88, .83	Victoria, B.C.	X: 2.23 Y: .96
Wellington, B.C.	X: 1.78, 2.22, 2.33, 2.37, 2.14, 2.00 Y: .95, 1.15, .73, 1.20, 1.42, 1.11		
Vancouver, B.C.	X: 2.06, 2.28, 2.48, 1.80 Y: 1.16, 1.23, .69, 1.13	Cultus Lake, B.C.	X: 2.60 Y: 1.12
west central British Columbia			
Oliver, B.C.	X: 1.89 Y: .71	Summerland, B.C.	X: 2.53, 2.81, 2.36, 2.66, 2.60 Y: .95, .82, .85, .92, .77
Vernon, B.C.	X: 2.29 Y: 1.18	Canoe, B.C.	X: 1.87 Y: .68
east central British Columbia			
Kaslo, B.C.	X: 2.14, 2.62, 2.50, 2.31, 1.96, 2.14, 2.53, 3.09 Y: .64, .71, .75, .65, .66, .55, .94, .93		
Robson, B.C.	X: 2.81, 2.38 Y: 1.04, .90		
Rocky Mountains			
Field, B.C.	X: 2.60 Y: .66	Banff, Alta.	X: 2.62 Y: .77
		Millarville, Alta.	X: 2.45 Y: .84
Head of Pine Creek, Calgary, Alta. X: 2.29, 2.47, 2.50, 2.36, 2.36, 2.32, 2.27, 2.23, 2.42, 2.61, 2.49, 2.14, 2.39, 2.17 Y: .67, .76, .71, .60, .69, .58, .57, .85, .63, .98, .67, .75, .78, .79			
C. <i>Diarsia pseudorosaria</i> Hdwk. (transition)		Nordegg, Alta.	
Nordegg, Alta.	X: 2.11, 1.83, 2.21, 1.68, 2.60, 1.30, 1.90, 1.04, 1.86, 2.00, 1.47 Y: .71, .67, .66, .42, .94, .25, .66, .32, .64, .51, .33		
D. <i>Diarsia pseudorosaria freemani</i> Hdwk.		northern coniferous forest	
Edmonton, Alta.	X: 1.41, 1.17, 1.11 Y: .39, .24, .29	Saskatoon, Sask.	X: 1.56, 1.38, 1.56 Y: .32, .20, .30
Hopedale, Labr.	X: 1.65, 1.37, 1.62, 1.30, 1.28, 1.13, 1.50, 1.32 Y: .39, .16, .30, .20, .34, .24, .34, .25		

TABLE II

THE MEANS AND STANDARD DEVIATIONS OF X (SLENDERNESS OF HARPE) AND Y (SIZE OF AMPULLA)
FOR THE GROUPS OF VALUES LISTED IN TABLE I.

Geographic Grouping	No. of Specimens	X		Y	
		Mean	S.D.	Mean	S.D.
North Coastal California..... (<i>rosaria</i>)	13	2.64	.20	.72	.07
Gresham, Oreg..... (<i>pseudorosaria pseudorosaria</i>)	10	2.16	.19	1.00	.06
Coastal British Columbia..... (<i>pseudorosaria pseudorosaria</i>)	20	2.23	.27	1.02	.20
(Gresham and Coastal B.C.....)	30	2.21	.24	1.01	.16)
West Central British Columbia..... (<i>pseudorosaria pseudorosaria</i>)	8	2.34	.33	.85	.15
East Central British Columbia..... (<i>pseudorosaria pseudorosaria</i>)	10	2.41	.32	.77	.16
Rocky Mountains..... (<i>pseudorosaria pseudorosaria</i>)	17	2.39	.14	.72	.10
(East Central B.C. & Rocky Mountains.....)	27	2.40	.23	.74	.13)
Nordegg, Alta. (Transition Zone) ... (<i>pseudorosaria</i>)	11	1.76	.37	.54	.20
Northern Coniferous Forest..... (<i>pseudorosaria freemani</i>)	14	1.37	.17	.28	.07

TABLE III

VALUES OF X (SLENDERNESS OF HARPE) AND Y (SIZE OF AMPULLA) FOR THE GROUPS FROM VARIOUS GEOGRAPHIC AREAS.

[illegible]

Because of similarly low t values, the Rocky Mountain and east central British Columbia samples have also been combined.

It will be noted that the t value for Y for the Rocky Mountain and the coastal British Columbia samples is 6.1 (highly significant), for the Rocky Mountain and west-central British Columbia sample 2.1 (significant) and for the Rocky Mountain and east-central British Columbia .9 (not significant). Between adjacent regions in this series, furthermore, the t value for Y never reaches a point of high significance. This condition, together with the changing values of the mean of Y for these populations, strongly suggests that a cline in the size of the ampulla exists over this area, the structure becoming smaller in successive populations from west to east. A similar, although weaker trend, may be noted for the length of the harpe.

The cline in the size of the ampulla continues eastward and northward into the northern coniferous forest, the change in the size of the structure becoming very marked at Nordegg, Alta., and presumably at similar points in the transition area between the Cordilleran region and the northern coniferous forest.

In the rather limited series of Nordegg material available, the individual specimens tend to group themselves, on the basis of the shape of the harpe and the size of the ampulla, either with *freemani* or with *pseudorosaria*. There is no decided clustering of the variates about their means. On the basis of present evidence, if a sufficiently large sample of the Nordegg population were examined, the distribution curves for X and Y might be bimodal as a result of some genetic factor in the population working to separate the two forms. This divergence from a normal distribution would tend to falsify the values of the standard deviation and of t . Consequently, where the Nordegg material is involved, these values have been bracketed in Tables II and III.

A sterility barrier may have been established already between *p. pseudorosaria* and *p. freemani*, thus fixing the two as distinct species. If such be the case the Nordegg material represents a mixed population, part *pseudorosaria* and part *freemani*, the two species occupying an area in which their ranges overlap.

Rosaria is distinguished from populations of *pseudorosaria* by the slenderness of the harpe. The mean of X for *rosaria*, 2.64, exceeds that for the eastern British Columbia and western Alberta sample of *pseudorosaria*, 2.40, the latter being the longest in all populations of that species that I have measured. The mean value of Y for *rosaria*, however, is essentially the same as that for the eastern British Columbia and western Alberta sample of *pseudorosaria*.

If *rosaria* were part of the cline which constitutes *pseudorosaria* one would expect that the parts of the male genitalia under consideration would be similar to those of the Gresham and coastal British Columbia population or an exaggeration of that type. The fact that *rosaria* does not comply with these requirements lends strength to the conclusion, arrived at on the basis of maculation and colouring, that *rosaria* is a distinct species.

To propose that the stock from which the *rosaria-pseudorosaria* group originated, closely approximated the eastern British Columbia population of today, at least in the structure of the harpe and the ampulla, may be a reasonable hypothesis. The mean of this population occupies a position close to the mean of all populations comprising the *rosaria-pseudorosaria* group. The relative closeness of the coastal California *rosaria* to the mean of the complex might be explained on the premise that a number of the original stock entered the coast of California and became established as a species before subsequent divergence in the harpe and ampulla occurred in the remainder of the group.

The Effect of Jack-pine Staminate Flowers on the Size of Larvae of the Jack-pine Budworm, *Choristoneura* sp.

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The jack-pine budworm, *Choristoneura* sp., was first recorded by Graham (5, 6) as a new variety or race on jack pine. Subsequent studies by Graham (6) showed that in the early stages of their development the larvae of this insect prefer jack-pine staminate flowers as a habitat. Population records from Manitoba and northwestern Ontario indicate that infestations of the jack-pine budworm are invariably associated with an abundance of staminate flowers.

Intensive studies have been carried out to determine how and why an abundance of staminate flowers is correlated with increases in populations of the jack-pine budworm. An attempt has been made to evaluate the influence of this factor on the various phases of the development of this insect. This paper presents but one aspect of these studies, the influence of jack-pine staminate flowers on the size of larvae. It deals with larval growth from the second to the ultimate stadium. The first-stage larvae do little or no feeding. The larvae pass the winter in the second stage. They emerge in the following spring and most of them concentrate upon available staminate flowers, though a small number begin feeding on new terminal shoots. Those larvae in the staminate flowers remain in them until the fourth or fifth stadium, when a sudden mass migration to foliage takes place. Some individuals, however, may inhabit staminate flowers during their entire larval and pupal periods.

This study was initiated on the premise that if it could be established that larvae which occupied staminate flowers during all or part of their feeding period grew to a larger size than those which fed exclusively on foliage, differences in fecundity, vigour, and survival might also be expected.

Growth ratio, as used in this paper, refers to the relative increase in size between successive larval instars. It was found that, in general, head capsule widths of jack-pine budworm larvae conformed with established growth laws (1, 2, 3, 8, 9), and they were therefore used as the basis of comparison in this study.

Methods

The larvae for this study were collected from jack-pine staminate flowers and foliage at Hawk Lake, Ontario, in 1943. Collections were made at two- or three-day intervals throughout the period of larval development, from the time of appearance of second-stage larvae in the spring to completion of pupation in July. The risk of collecting larvae which might have migrated from flowering to non-flowering trees was reduced by gathering larvae feeding on foliage from young jack pines which were at least fifty feet removed from the nearest pollen-bearing trees. However, in the year in which these collections were made, budworm populations were at a low level and there was little evidence of migration from flowering to non-flowering trees.

Subsequently, the larvae were segregated according to sex, and head capsule widths were measured with a binocular and a monocular microscope. Head capsule widths of second- to fourth-stage larvae were measured accurately to 0.07 mm. and interpolated to 0.007 mm., and the larger larvae were measured accurately to 0.22 mm. and interpolated to 0.02 mm. First-stage larvae were not included.

TREATMENT OF DATA

Determination of Stadia

It was found that when the larvae were segregated according to food type and sex, their head capsule widths fell into well defined, usually discrete, frequency distributions. The general appearance of the larvae usually provided further evidence as to instars.

A major exception was encountered in male larvae, for which the frequency distributions of the fifth and succeeding stadia, except the last, overlapped. More will be said about this later. Aside from this exception, however, the stage of a larva was identified by its head capsule width.

Calculation of Growth Ratios

Theoretical growth ratios were calculated from the observed measurements. Four methods were tested; and the method of least squares, using the standard regression formula $\log Y = a - bx$, was selected as the most accurate (necessarily so by definition) and the most readily adapted to statistical analysis. Dyar's law (2) proved inadequate.

Two methods giving very close approximations to results obtained by applying the linear regression formula were used. These are simple to apply and should be useful in preliminary calculations of theoretical growth ratios. They are, therefore, explained briefly.

The first method involves the computation of the ratio of growth between succeeding stadia in a series. The average head capsule width of each stadium is divided into the average head capsule width of the succeeding stadium. The individual ratios between successive instars are then totalled and averaged to give a theoretical growth ratio.

The second method involves the use of logarithms. As the observed head capsule widths are in geometric progression and closely follow the so-called law of organic growth (10), a growth ratio is easily computed by means of logarithms according to the following formula:—

$$\log R = \frac{\log L - \log S}{M}$$

where: R = growth ratio

L = average head capsule width of the last instar

S = average head capsule width of the second instar

M = number of moults between L and S, in this case, 5.

In addition to its simplicity, this method has the advantage of requiring the average head capsule widths of only two stadia, the first and the last in the series, but the number of intervening moults must be known.

A comparison of the accuracy of the four methods described above is shown in Table I. For illustration, the head capsule widths of female larvae collected from foliage were used for determining theoretical growth ratios.

Results

Figs. 1 and 2 show the frequency distributions of all head capsule widths measured. Those for female larvae are shown in Fig. 1 and those for male larvae in Fig. 2. Although the actual head capsule widths were used, the classes on the x axis correspond to a logarithmic series; that is, the class intervals become progressively larger toward the later stadia.

Fig. 1 shows that for female larvae the head capsule widths fall into six discrete frequency distributions, indicating the presence of six stadia, the second to the seventh. As these frequency distributions are so well defined, it was considered valid to identify the stage of a female larva according to the frequency curve in which the head capsule width fell.

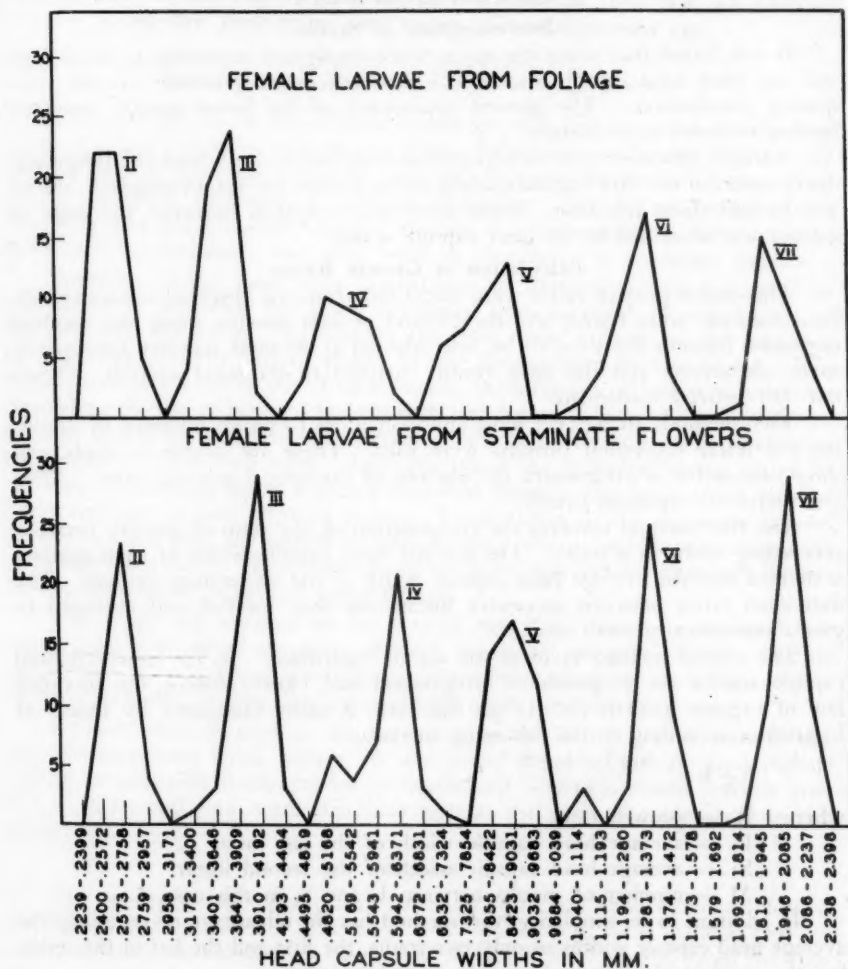


FIG. 1. Graphs showing frequency distributions of head capsule widths of female larvae of the jack-pine budworm collected from foliage and from staminate flowers.

The separation of stadia of male larvae is not so simple (Fig. 2). Each frequency curve in Fig. 2, characterized by a pronounced modal point, is identified by a letter. The series from foliage and that from staminate flowers are similar in the configuration of modal points.

Curves *a*, *b*, and *c* represent the second, third, and fourth stadia respectively and present no particular difficulty in the separation of stadia. The same applies to the discrete distribution of curve *g*, representing the ultimate stadium.

The main difficulty in separating stadia occurs in curves *d*, *e*, and *f*, and the following explanation is offered. It is believed that fourth-stage male larvae moult into two types of fifth-stage larvae, a smaller represented by curve *d* and a larger represented by curve *e*. The smaller type then moult successively into

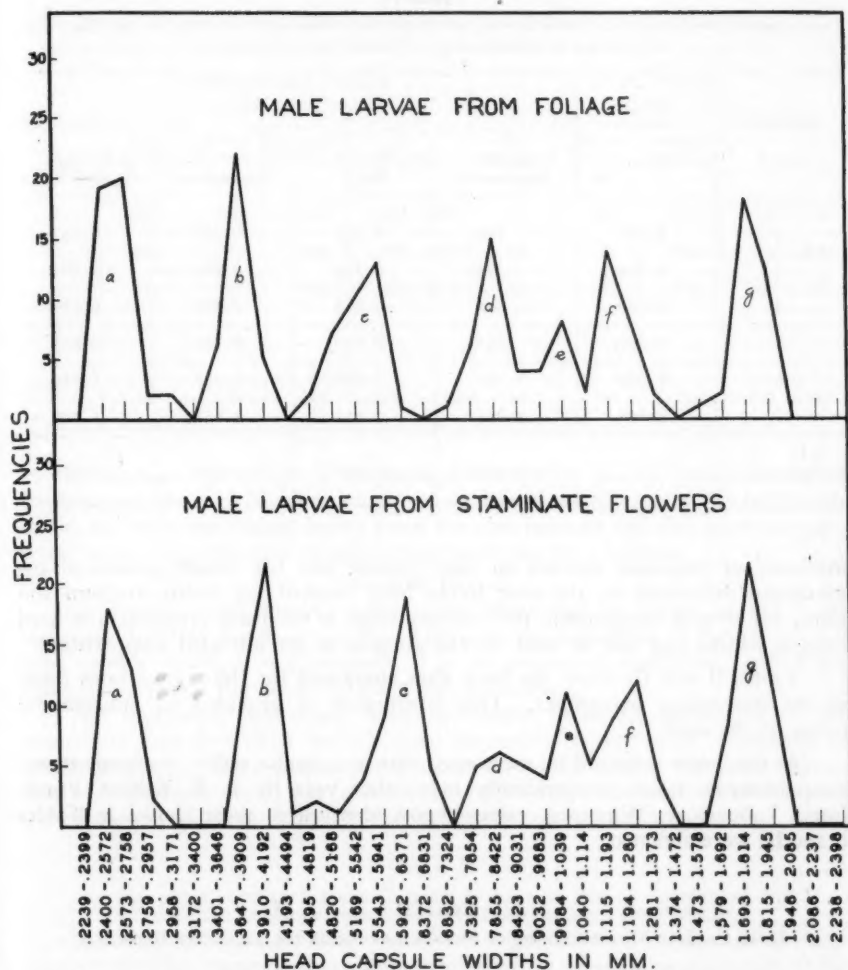


Fig. 2. Graphs showing frequency distributions of head capsule widths of male larvae of the jack-pine budworm collected from foliage and from staminate flowers.

a usual sixth (curve *f*) and the ultimate stage (curve *g*). The larger type, on the other hand, apparently undergo but one more ecdysis in larval development and change directly into the ultimate stage (curve *g*). They seem to skip the sixth stage, which is normal to nearly all female larvae and to about 50 per cent of males. There appears to be no correlation between feeding site and the occurrence of six or seven stadia in the male larvae.

The above explanation is supported by evidence on sex ratios, by date of appearance of the various stadia in field collections, and by individual larval rearings.

The merging of curves *d*, *e*, and *f* renders it impossible, by head capsule size alone, to differentiate accurately the stages involved. Nevertheless, since the

TABLE I

COMPARISON OF THEORETICAL WITH ACTUAL HEAD CAPSULE WIDTHS OF LARVAE OF THE JACK-PINE BUDWORM DETERMINED BY FOUR DIFFERENT METHODS.

Stadium	Actual Widths (mm.)	CALCULATED WIDTHS			
		Linear Regression	Dyar's Ratio	Logarithms	Average Growth Ratio
2	0.261	.246	0.261	0.261	0.261
3	0.366	.371	0.366	0.392	0.392
4	0.532	.559	0.513	0.588	0.589
5	0.807	.843	0.719	0.882	0.885
6	1.286	1.270	1.008	1.323	1.330
7	1.989	1.913	1.414	1.984	1.999
S.E. Estimate	—	0.037	0.263	0.042	0.045

influence of staminate flowers on head capsule size has usually produced the maximum difference by the time larvae have reached the fourth stadium and since, for overall comparison, the ultimate stage is the main criterion, the head capsule widths may still be used for the purpose of the intended comparisons.

Tables II and III show the basic data employed for the comparisons made in the succeeding paragraphs. This information is provided to indicate the scope of the study.

At this point it should be mentioned that in a similar series of measurements (unpublished), made independently in another year by F. B. Rabkin, Forest Insect Laboratory, Winnipeg, values almost identical to those shown in Tables II and III were obtained.

TABLE II
HEAD CAPSULE MEASUREMENTS OF FEMALE LARVAE OF THE JACK-PINE BUDWORM

Stadium	From Staminate Flowers				From Foliage			
	No. Measured	Mean Width mm.	Standard Deviation	Range	No. Measured	Mean Width mm.	Standard Deviation	Range
2	38	.265	.011	.245-.298	49	.261	.011	.240-.296
3	50	.392	.019	.317-.429	49	.366	.020	.317-.419
4	42	.590	.047	.493-.699	32	.532	.040	.450-.622
5	43	.870	.505	.785-.968	35	.807	.059	.699-.903
6	37	1.340	.047	1.251-1.472	36	1.286	.082	1.040-1.472
7	49	2.016	.082	1.773-2.185	55	1.989	.071	1.773-2.185

TABLE III
HEAD CAPSULE MEASUREMENTS OF MALE LARVAE OF THE JACK-PINE BUDWORM

Stadium	From Staminate Flowers				From Foliage			
	No. Measured	Mean Width mm.	Standard Deviation	Range	No. Measured	Mean Width mm.	Standard Deviation	Range
2	33	.266	.001	.245-.282	45	.262	.014	.234-.310
3	38	.396	.020	.364-.460	33	.377	.013	.356-.419
4	38	.598	.036	.505-.683	33	.542	.036	.449-.622
5	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—
7	42	1.775	.081	1.579-1.945	33	1.786	.083	1.507-1.945

To compare the effect of staminate flowers with that of foliage on larval development, the data have been analyzed to determine differences (a) in growth curves for male and female larvae from the two habitats and (b) between individual stadia for male and female larvae from the two habitats.

Growth Curves

As already stated, growth ratios were determined by means of the linear regression formula $\log y = a - bx$. $\log y$ is the logarithm of the theoretical head capsule width, a is a constant, b is the regression coefficient, and x the stadium for which the head capsule width is required.

The regression coefficients were calculated from the logarithms of the mean head capsule widths, and the final theoretical widths were transposed to actual numbers. This transposition is necessary for calculating the linear regression of a normal growth curve since the actual values are curvilinear whereas the logarithms of these values tend to be distributed in a straight line.

TABLE IV
ACTUAL AND CALCULATED HEAD CAPSULE WIDTHS OF FEMALE LARVAE OF THE JACK-PINE BUDWORM FROM STAMINATE FLOWERS AND FROM FOLIAGE.

Stadium	From Staminate Flowers		From Foliage	
	Actual	Calculated	Actual	Calculated
2	.265	.262	.261	.246
3	.392	.394	.366	.371
4	.590	.591	.532	.559
5	.870	.887	.807	.843
6	1.340	1.332	1.286	1.270
7	2.016	2.000	1.989	1.913
Regression Coefficients		0.1765		0.1780

Tables IV and V show the actual and calculated head capsule widths as determined by the linear regression method. Only the second, third, fourth, and last stadia were used in the calculation of coefficients for male larvae.

The difference between the regression coefficients for female larvae from staminate flowers and for those from foliage is not statistically significant. The same lack of significance applies to male larvae. Hence, it must be concluded that there is no overall difference in the effect of staminate flowers on larval size as indicated by head capsule widths.

TABLE V
ACTUAL AND CALCULATED HEAD CAPSULE WIDTHS OF MALE LARVAE OF THE
JACK-PINE BUDWORM FROM STAMINATE FLOWERS AND FROM FOLIAGE.

Stadium	From Staminate Flowers		From Foliage	
	Actual	Calculated	Actual	Calculated
2	.266	.271	.262	.257
3	.396	.396	.377	.378
4	.598	.578	.542	.556
5	—	—	—	—
6	—	—	—	—
7	1.775	1.799	1.786	1.776
Regression Coefficients		0.1643		0.1673

Nevertheless, though the average growth coefficients are the same for larvae of the same sex from staminate flowers and from foliage, noticeable differences in average size of head capsules are evident between some of the individual larval stadia. To determine the stadia in which significant differences in size occur, the statistical "t" test (4) was applied to individual stages. The actual head capsule widths were used in these comparisons. The results of the analyses are summarized in Tables VI and VII.

In Table VI, the head capsule widths of third-, fourth-, and fifth-instar female larvae from staminate flowers are significantly larger than those from foliage, whereas those of the second, sixth, and seventh stadia are not. The same applies to the male larvae in Table VII for stadia in which the average size of the head capsule can be determined, no comparison being possible between the "fifth" and "sixth" stadia.

When this study was initiated, it was assumed that any beneficial effect which staminate flowers might have on budworm development would be due to the nutritional advantages of a partial or complete pollen diet. Recently, however, evidence has been obtained which indicates that a more favourable microclimate provided by the staminate flowers may be as important as, or more important than, the nutritional factor. If this should prove true, it could be argued that a favourable microclimate might not produce the same fundamental physiological differences that might be expected to result from a more nutritious diet. This would simplify studies on the influence of staminate flowers on the epidemiology of the jack-pine budworm because differences would probably

TABLE VI
SIGNIFICANCE OF DIFFERENCES IN HEAD CAPSULE WIDTHS OF FEMALE LARVAE OF THE
JACK-PINE BUDWORM COLLECTED FROM STAMINATE FLOWERS AND FROM FOLIAGE.

Stadium	From Staminate Flowers		From Foliage		Differences %	t	Values of t at Significant Levels	
	Av. Width	No. Measured	Av. Width	No. Measured			5%	1%
2	.265	38	.261	49	1.53	1.61	1.99	2.64
3	.392	50	.366	49	7.10	6.43*	1.98	2.65
4	.590	42	.532	32	10.90	5.71*	2.00	2.65
5	.870	43	.807	35	7.81	5.11*	1.99	2.64
6	1.321	40	1.286	36	2.72	1.81	1.99	2.64
7	2.016	49	1.989	55	1.36	1.71	1.98	2.63

*Significant.

TABLE VII
SIGNIFICANCE OF DIFFERENCES BETWEEN HEAD CAPSULE WIDTHS OF MALE LARVAE OF
THE JACK-PINE BUDWORM COLLECTED FROM STAMINATE FLOWERS AND FROM FOLIAGE.

Stadium	From Staminate Flowers		From Foliage		Differences %	t	Values of t at Significant Levels	
	Av. Width	No. Measured	Av. Width	No. Measured			5%	1%
2	.260	33	.262	45	0.76	0.65	1.99	2.64
3	.396	38	.377	33	5.04	4.64*	2.00	2.65
4	.598	38	.542	33	10.33	5.33*	2.00	2.65
5	—	—	—	—	—	—	—	—
6	—	—	—	—	—	—	—	—
7	1.775	42	1.786	33	0.62	0.62	2.00	2.65

*Significant.

occur chiefly in survival of larvae; these are more easily detected than differences in fecundity or vigor.

Nevertheless, regardless of the cause, the effect, as indicated in the preceding paragraph, can be readily associated with the habits of the larvae. In second-stage larvae no effect of staminate flowers on the size is to be expected since they have had no previous opportunity to develop in or on staminate flowers. Those spring emergents which inhabit staminate flowers, presumably for food and shelter, generally remain in the flowers through the second, third, fourth, and perhaps part of the fifth instars.

Although most of the pollen is shed by the completion of the third larval stage, a certain residue of pollen remains in the flowers, and the stroboli adhere into early summer. Moreover, the larvae usually remain in their webs, inside the

flowers, leaving them periodically in the later stages prior to migration to feed on foliage. It is during this period, when the larvae occupy the staminate flowers, that the differential growth in head capsule size occurs.

When the larvae reach the late fourth or early fifth larval stage, a definite migration from staminate flowers to foliage takes place. This migration is followed by a decrease in the growth ratio of larvae which formerly occupied the flowers with the result that in the sixth and seventh stages the head capsule widths are no longer significantly greater than those of larvae that have fed on foliage.

In view of this, it seems that if larval size is regarded as a manifestation of fundamental physiological differences, such differences are not likely to occur. For example, unpublished data on the reproductive capacity of jack-pine budworm moths indicate that access to staminate flowers during larval development has no significant effect on reproductive potential.

Other unpublished results obtained by W. F. Black, Forest Insect Laboratory, Winnipeg, and the author indicate that second-stage larvae which inhabit staminate flowers after emerging from their hibernacula in the spring have a higher rate of survival than those living on foliage. It is suggested that this higher survival is the primary cause for the close association between the abundance of staminate flowers and of the jack-pine budworm observed in several infestations in Manitoba and northwestern Ontario. Results of population studies showing evidence of this correlation have been prepared for publication. Whether the higher survival is due to nutritional or ecological considerations is a point which remains to be settled.

Conclusions

(1) Head capsule widths of male and female larvae of the jack-pine budworm follow the laws of organic growth and increase in geometric progression. Theoretical growth rates were calculated by four different methods, the most accurate being the method of least squares. Calculated regression lines gave the best, and, at the same time, a significant fit to the observed data.

(2) Head capsule widths of female larvae of the jack-pine budworm fall into discrete frequency distributions permitting the classification of larval stadia by this method.

(3) The head capsule widths of male larvae fall into discrete frequency distributions for second-, third-, fourth- and last-stage larvae only. Evidence indicates that about 50 per cent of the male larvae pass through six stages, the remainder passing through seven.

(4) There is no significant difference between the overall growth coefficients of larvae gathered from staminate flowers and of those from foliage, calculated by the linear regression methods.

(5) The head capsule widths of third-, fourth-, and fifth-stage female larvae from staminate flowers were significantly larger than those of female larvae from foliage; this was not so with second-, sixth-, and seventh-stage larvae.

(6) Head capsule widths of third- and fourth-stage male larvae from staminate flowers were significantly larger than those of male larvae from foliage, whereas the second and last were not. The remaining instars could not be properly segregated for statistical tests.

(7) While larvae occupy staminate flowers, the growth ratio is greater than that of larvae feeding on foliage, but any gains in growth are lost following migration to foliage in the fourth and fifth stages.

(8) It is not known whether staminate flowers benefit budworm larvae by providing a more nutritious diet or a more favourable microclimate. Perhaps the observed effect is produced by a combination of both.

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The Uses of Parathion in British Columbia Orchards¹

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In British Columbia parathion was first officially recommended to the fruit grower in 1949 for the control of orchard insects and mites, particularly the pear psylla, *Psylla pyricola* Foerst.; the European red mite, *Metatetranychus ulmi* (Koch)=[*Paratetranychus pilosus* (C. & F.)]; and the Pacific mite, *Tetranychus pacificus* McG. Similar recommendations were made simultaneously in other Canadian fruit-growing areas. In British Columbia the Okanagan Spray Committee advised the use of only one formulation and one concentration: 15 per cent wettable powder at 0.75 pounds per 100 imperial gallons. At the start of the season most growers were rather reluctant to use parathion, not necessarily because it was new but because the poisonous nature of the material had been so thoroughly impressed upon them. However, as the season progressed and orchard pests became generally more troublesome, their attitude changed, so that by mid-season the use of parathion was common. It is estimated that at least 75 per cent of Okanagan Valley fruit growers used this insecticide at one time or another during the season. They bought from 40 to 50 tons of 15 per cent parathion wettable powder in 1949.

Parathion was first made available to the Summerland entomological laboratory for experimental purposes in 1947. Some investigational work was done with it that year, mainly on mites. In 1948 and 1949 it was widely tested on mites and on a number of other orchard insect pests. The authors were responsible for the work on mites; M. D. Proverbs directed the investigations on soft-fruit insects. Chemical analyses were made by J. M. McArthur and J. R. W. Miles.

Control of Fruit Insects with Parathion

The European Red Mite

Preliminary experiments in 1947 indicated that parathion was very promising for the control of the European red mite. For example, 0.5 pounds³ of the 15 per cent wettable powder applied in July to Delicious apple trees reduced the average number of mites per leaf from 75.6 to 1.8 in 5 days; 13 and 26 days after spraying, mites had increased to 6.7 and 8.3, respectively. In another experiment on Delicious and McIntosh apple trees and Anjou pears the same concentration reduced the average number of active mites per leaf from 58.3 to 0.2 in 4 days; 19 and 34 days after application, mites had increased to 3.6 and 24.7, respectively. In both experiments parathion was used alone.

In 1948 more extensive tests were made on Delicious trees with parathion alone, and combined with DDT and with the adhesive polyethylene polysulphide. These materials were added to the regular codling moth summer sprays, of which three were applied. Effectiveness of each application was determined by sampling the leaves for mites both before and after spraying. From these records a seasonal average of the number of mites per leaf was calculated. Counts of winter eggs were made after the leaves had fallen. One of the chief points was to compare parathion with the currently recommended mite spray of monoethanolamine dinitro-o-cyclohexylphenolate, commonly called Mono DNP by British Columbia growers. At harvest, samples of fruit were taken for chemical determination of parathion residue. Results are summarized in Table I.

Tests on a smaller scale were conducted in other orchards with somewhat similar results. The following conclusions drawn from the 1948 experiments

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³All concentrations are for 100 imperial gallons (120 U.S. gallons).

TABLE I.

EFFECT OF THREE SUMMER SPRAYS OF PARATHION ON THE EUROPEAN RED MITE
AND PARATHION RESIDUE ON FRUIT AT HARVEST.

Material	Amount per 100 gals.	Season average number of mites per leaf	Winter eggs deposited per one-inch fruit spur	Parathion residue at harvest as p.p.m.
15% Parathion ¹	2 lb.	4.5	28.2	0.045
50% DDT	1 lb.	7.7	581.6	0.010
15% Parathion	0.5 lb.			
50% DDT	0.5 lb.	10.8	377.7	0.002
15% Parathion	0.25 lb.			
Polyethylene polysulphide ²	0.5 lb.			
50% DDT	1 lb.	5.4	26.1	
40% Dinitro-o-cyclo- hexylphenol ³	5 oz.			
Monoethanolamine	1 oz.			
Check — no treatment		19.0	35.9	

1. THIOPHOS—American Cyanamid Co., New York, N.Y.

2. GOOD-RITE P.E.P.S.—B. F. Goodrich Chemical Co., Cleveland, Ohio.

3. DN-DRY MIX No. 1.—Dow Chemical Co., Midland, Mich.

must be tempered by the fact that control of the European red mite was a relatively easy problem that year. 1. Fifteen per cent parathion wettable powder at 0.5 pounds was the minimum concentration to give commercial control where the European red mite was not a difficult problem. Four or six ounces were not sufficient. 2. At 0.5 pounds, three summer sprays of 15 per cent parathion were required to control the mites. 3. Use of that quantity of parathion in three summer sprays might create a mite problem the following year, because, so applied, it either permitted or, more probably, promoted the deposition of great numbers of European red mite winter eggs. The following spring, before the first cover spray, commercial mite damage resulted where this amount of parathion had been used.

Although mite control from 0.75 pounds of 15 per cent parathion was generally better in 1949 than the growers had previously obtained with other acaricides, there were, nevertheless, many disappointments. In some cases initial control was poor and in many more instances there was practically no residual protection. In the experimental work of 1949, one pound of 50 per cent DDT wettable powder was included with all concentrations or combinations of parathion. Three sprays were applied: May 26, June 13, and August 15. At harvest the fruit was analyzed for parathion residues. No records of mite populations were taken after the last spray. The results of the 1949 trials are shown in Table II.

Records of winter eggs on trees that received the above treatments in Table II have not yet been made, but observation indicates that large numbers of eggs have been laid where 0.75 pounds of parathion was used in three summer sprays. Apparently 0.75 pounds of parathion with the addition of one quart of stove oil seemed only slightly less effective than 2.25 pounds of parathion alone. Where five ounces of 40 per cent dinitro-o-cyclohexylphenol was added to 0.25 pounds of parathion, control apparently was distinctly better than from 0.75 pounds of parathion alone. Such a combination would cost less than 0.75 pounds of parathion. In all plots control of the woolly apple aphid was very satisfactory.

TABLE II.
EFFECT OF TWO SUMMER SPRAYS OF PARATHION¹ ON THE EUROPEAN RED MITE AND
PARATHION RESIDUE ON FRUIT AT HARVEST

Material	Amount per 100 gals.	Season average number of mites per leaf	Parathion residue at harvest as p.p.m.
15% Parathion	0.25 lb.	8.9	< 0.01
15% Parathion	0.75 lb.	2.3	0.02
15% Parathion	0.25 lb.	1.3	
40% Dinitro-o-cyclo- hexylphenol	5 oz.		
15% Parathion Stove oil ²	0.75 lb. 1 qt.	0.7	
15% Parathion	2.25 lb.	0.6	0.18
40% Dinitro-o-cyclo- hexylphenol	5 oz.	1.6	
Monoethanolamine	1 oz.		
40% Dinitro-o-cyclo- hexylphenol	5 oz.	3.6	
50% DDT	1 lb.	6.8	
Check — no treatment		4.6	

1. 1 lb. of 50% DDT wettable powder included with each treatment.

2. 34 S.S.U., Vis. 100° F., over 75% U.R.

Where parathion has been used for the control of the European red mite, control of the Pacific mite has been excellent, but it might be mentioned here that there are indications that the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, may be producing parathion-resistant strains.

In 1950, many British Columbia growers will apply parathion in the pink stage of apple for control of the European red mite. In two years of experimental work, parathion as a "pink" application gave better control of this mite than either a dormant spray of heavy oil (2%)⁴—lime sulphur (4%) or a first cover spray of parathion. In fact, where this mite is not a particularly difficult problem, the "pink" spray of parathion should, in all probability, eliminate the need of summer sprays for this mite in DDT-sprayed orchards. Where the problem is more difficult, parathion applied in the pink stage and once in late summer should give control of the mite on apples and pears in the majority of orchards. In British Columbia many growers must apply lime sulphur as a "pink" application for control of powdery mildew or apple scab. Contrary to common opinion, experimental work in the field has indicated that parathion and lime sulphur can be applied simultaneously without detriment to the effectiveness of parathion. In 1949, a "pink" spray of parathion was applied in three hand-sprayed orchards to the following apple varieties: Stayman, Newtown, Winesap, Delicious, McIntosh, Wealthy, and Jonathan. Each orchard received two DDT summer sprays. Mite populations were sampled two weeks, one month, two months, three months, and four months after the "pink" application. The results from one of these orchards are given in Table III; they are typical of the other two orchards.

⁴The officially recommended oil in British Columbia, 200-220 S.S.U., Vis. 100° F.

TABLE III.
EFFECT OF "PINK" APPLICATION OF PARATHION ON THE EUROPEAN RED MITE

Material	Amount per 100 gals.	Season average number of mites per leaf
15% Parathion.....	0.75 lb.	0.16
15% Parathion	0.75 lb.	0.06
Lime sulphur.....	1.25 gal.	
15% Parathion.....	0.75 lb.	0.02
Wettable sulphur.....	6 lb.	
Dormant oil.....	2 gal.	4.16
Lime sulphur.....	4 gal.	
Check — no treatment.....		16.19

The Woolly Apple Aphid

During the past season, growers' results with 0.75 pounds of parathion wettable powder for control of the woolly apple aphid, *Eriosoma lanigerum* (Hausm.), were extremely variable. Experimental evidence has indicated that at least one pound is required for satisfactory results. Timing of sprays may play an important role. In many cases, two applications of parathion in the regular DDT codling moth schedule has given adequate summer control of this aphid. However, where no control is attempted until midsummer and a severe infestation develops, one or more sprays at higher concentrations may be required for commercial control.

Thorough wetting of aphid colonies is still a prerequisite if parathion is applied by the conventional method. Where the same material is applied by a concentrate machine, drenching has not appeared to be necessary. For example, eight pounds of 15 per cent parathion wettable powder per acre applied with a concentrate sprayer has given excellent results. Fumigant action may play a part in such applications. The addition of one or two gallons of stove oil per acre substantially increased the toxicity of parathion to this aphid and, as previously noted, to the European red mite.

The Green Apple Aphid

The green apple aphid, *Aphis pomi* De G., has been a most difficult insect to kill with parathion. Two and one-quarter pounds of 15 per cent parathion wettable powder applied in three codling moth cover sprays, two in the first brood and one in the second, has not given any appreciable control of this insect.

The Mealy Plum Aphid

Control by growers of the mealy plum aphid, *Hyalopterus arundinis* (F.), with 0.75 pounds of 15 per cent parathion wettable powder was somewhat erratic. Generally results were better than from 0.75 pints of 40 per cent nicotine sulphate plus three pounds of soap. Investigational work showed that parathion at that concentration gave excellent summer control of the mealy plum aphid where the infestation was not serious, but in very severe infestations control was not satisfactory. The results of one experiment are shown in Table IV. Sprays were applied on May 25 and aphid counts were made on June 18.

The Black Cherry Aphid

Recent experiments indicate that for control of the black cherry aphid, *Myzus cerasi* (F.), 0.75 pounds of 15 per cent parathion alone or with heavy oil,

TABLE IV.
EFFECT OF PARATHION AND NICOTINE SULPHATE ON CONTROL
OF THE MEALY PLUM APHID

Material	Amount per 100 gals.	Average number aphid colonies per tree
15% Parathion.....	0.75 lb.	0.3
40% Nicotine sulphate Soap.....	0.75 pt. 3 lb.	6.8
Check — no treatment		22.0

applied in the delayed dormant stage of cherries, may be substituted for the currently recommended dormant spray mixture of heavy oil and dinitro-o-cresol. Where the dormant spray is not desired, parathion at the same rate applied as a petal-fall spray has given satisfactory control until harvest.

In several experiments in 1949, 0.75 pounds of 15 per cent parathion as a summer spray consistently gave results superior to those from 0.75 pints of 40 per cent nicotine sulphate plus three pounds of soap; usually 100 per cent mortality was obtained with parathion.

The Tarnished Plant Bug

Fifteen per cent parathion wettable powder at seven pounds per acre, applied with a concentrate machine when about 75 per cent of the peach petals had fallen, has given control of plant bugs, *Lygus* spp., comparable to that from 15 pounds of 50 per cent DDT. Parathion is preferred for this purpose as use of DDT on stone fruits may create a subsequent mite problem.

The Peach Twig Borer

Promising control of the peach twig borer, *Anarsia lineatella* Zell., has been obtained when parathion was applied in the late pink stage of peaches. Application of 15 per cent parathion was made with a concentrate machine at the rate of approximately eight pounds per acre, or the equivalent of one pound per 100 gallons by the conventional method.

The San Jose Scale

Parathion applied at the crawler stage of development of the San Jose scale, *Aspidiotus perniciosus* Comst., has not shown promise for control of this insect. This year a test on prunes revealed that when dormant oil-lime sulphur was applied with the BES-KIL steam generator with blower, 0.3 per cent of the fruit was scale-infested at harvest. Where 15 per cent parathion was applied at six pounds per acre with the same machine on June 10, 35.2 per cent of the fruit was infested.

The Pear Psylla

The pear psylla, *Psylla pyricola* Foerst., is one insect most readily controlled with parathion. No commercial insecticide excels it for this particular pest. In the majority of orchards one early summer spray of 0.75 pounds of 15 per cent parathion wettable powder gave protection until harvest.

The Eye-Spotted Bud Moth

Complete mortality of an unusually severe infestation of the eye-spotted bud moth, *Spilonota ocellana* (D. & S.), on cherries was obtained in 1949 with 0.75 pounds of 15 per cent parathion wettable powder applied when the larvae were nearly mature. Benzene hexachloride, DDT, nicotine sulphate, and hexaethyl tetraphosphate, with which parathion was compared, were unsatisfactory.

Toxicity of Parathion to Plants

In Eastern Canada parathion has injured McIntosh apples, especially where it has been used in the early part of the season. Although parathion has been applied in the interior of British Columbia as early as the pink stage to a number of apple varieties including McIntosh, no injury has been experienced where the conventional method of application has been employed. Parathion wettable powder in a concentrate machine, however, has injured McIntosh foliage and fruit on some lower branches in one orchard of the Creston area. The emulsion form in a concentrate machine has seriously damaged pears and various varieties of apples. This type of parathion is not recommended in Canada.

Toxicity of Parathion to Beneficial Insects

Not many years ago, when lead arsenate and cryolite were in use, parasites and predators helped to maintain many of our orchard pests at reasonable population levels. When DDT was employed for codling moth control, immediately the biological balance of some of our insects and mites was upset, the best example of this being provided by the European red mite. General use of parathion will, in all probability, be detrimental to the majority of beneficial insects which DDT did not affect. Wherever both parathion and DDT have been used, most beneficial insects seem literally to have been wiped out. As things now stand the British Columbia orchardist seems committed to rely very largely on chemicals for control of practically all orchard pests.

Toxicity of Parathion to Man

No fatalities have yet occurred in British Columbia from the use of parathion, although several orchardists have become decidedly ill after using parathion in concentrate equipment without the use of an adequate respirator. For this reason the Okanagan Spray Committee is making every effort to impress upon growers the dangers involved in careless use of this material. Two organic vapour-dust type respirators, which have been used in British Columbia, appear to be suitable for orchard use and official approval of these is being sought. In the meantime arrangements are being made to have such respirators supplied as standard equipment with concentrate sprayers.

Conclusions

Investigational work conducted during the past three years has shown that in properly timed applications, parathion has effectively controlled the European red mite, the Pacific mite, the pear psylla, the woolly apple aphid, the black cherry aphid, the mealy plum aphid, *Lygus* spp., the peach twig borer, and the eye-spotted bud moth. British Columbia recommendations for the use of parathion in 1950 were based mainly on the minimum amount required to control the woolly apple aphid, perhaps the most resistant of these mites and insects. Experimental evidence and growers' experience have shown that a minimum amount of one pound of 15 per cent parathion wettable powder is required to give satisfactory results. For 1950, therefore, growers are being advised to use the one-pound concentration for control of all these orchard pests. This is to be used not later than thirty days before harvest of any crop. No residue problem is anticipated, as chemical analyses have demonstrated that three sprays of 2.25 pounds of 15 per cent parathion, the last as late as August 16, produced only 0.18 parts of parathion per million on apples at harvest.

A New Species of *Dytiscus* Linn. (Coleoptera, Dytiscidae)

By J. B. WALLIS
Winnipeg

For a number of years, at least one species of *Dytiscus*, apparently undescribed, has been in my collection.

Recently Professor M. H. Hatch asked me to describe this species in order that he might include it in his forthcoming book on *The Coleoptera of the Pacific Northwest*.

Although Balfour-Browne, 1935, pointed out that the correct spelling of the generic name is *Dyticus*, this does not seem to have been accepted, as in the 5th Supplement to the Leng Catalogue, *Dytiscus* is still used. I, therefore, use that spelling.

The North American species of this genus are in considerable need of study but only comparison with types will settle some questions. This is particularly true of the species having pointed hind coxal processes, those with rounded or blunt processes being more certainly determined.

Dytiscus (sub. gen. *Macrodytes*) *hatchi* sp. nov.

Holotype ♂: Length 25 mm., width 13 mm., shape much as usual, the greatest width at about the middle of the elytra.

Colour above, black, with a brownish tinge. Labrum and clypeus pale brown, the colour running up partly bordering the eye. Pronotum rather broadly bordered laterally, apically and basally with pale brown, these margins having a speckled appearance owing to some blackened punctures. Elytra laterally margined with pale brown, the colour obscured by blackish and by punctures. The pale brown scutellum margined outwardly with blackish.

Sculpture of head and pronotum very fine as usual, punctulation of elytra fine and widely separated basally, becoming rapidly closer and larger apically.

Colour below, including legs, a trifle darker brown than the pronotal margins, except the abdomen which is a little lighter. The hind tibiae and tarsi are a little darker brown and the abdominal segments are blotched laterally with very dark brown, these blotches not reaching the middle line nor the lateral margins.

Hind coxal processes broadly rounded.

Front tarsal claws long, the anterior one a little the longer and about 12% longer than the fifth tarsal joint.

The front tarsal dilated joints with two large disks, one much larger than the other, and the usual tiny disks crowded right down to the large ones.

Allotype ♀: Size, shape and colour as in holotype except that colour above is slightly more brownish. Punctulation similar. Elytra sulcate, the sulci about 2/3 total length of elytra. Fore tarsal claws similarly long.

Localities. Holotype: Pond N. of Bethel, Washington. Apr. 21, 1940 (no collector given).

Allotype: Mt. Arrowsmith, B.C., 18 III. 29, J. F. Clarke. Both in my collection. Paratypes: Washington 10 ♂ 22 ♀. Oregon 1 ♂ 5 ♀. California 4 ♂ 3 ♀. B.C. 22 ♂ 31 ♀.

This species does not seem to range very far north in British Columbia but is apparently abundant south of the C.P.R. main line. It has been taken as far east as Creston, and as far west as Vancouver Island which it probably inhabits as far north as Duncan.

There is little variation in size among these paratypes which, however, show considerable difference in colouring. Many have the elytra quite brownish, probably due to being teneral.

The dark blotches on the sides of some of the abdominal segments show much variation in degree of intensity and size. They can almost always be traced as a small darker shade on one segment or more, and usually are perfectly distinct forming a useful diagnostic character.

The species of *Dytiscus* sub. gen. *Macrodytes* with blunt or rounded hind coxal processes occurring in our Fauna can be readily separated thus:—

- | | |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| Size larger. Length 30 mm. and over..... | 1 |
| Size smaller. Length under 30 mm..... | 2 |
| 1. Black or piceous beneath. Pronotum not margined with yellow apically or basally..... | <i>verticalis</i> |
| Ferruginous beneath. Pronotum margined with yellow apically and basally..... | <i>cordieri</i> |
| 2. Black or piceous beneath. Dilated joints of ♂ middle tarsi with a longitudinal smooth space. ♀ ♀ always smooth..... | <i>hybridus</i> |
| Largely ferruginous or brownish piceous beneath..... | 3 |
| 3. Apex and especially base of pronotum not or faintly and narrowly margined with yellow. Apical yellow margin usually not over 20% of pronotal length, the basal margin usually less. Fainter than the apical. ♂ pro-tarsal claws scarcely $\frac{4}{5}$ the length of the 5th joint. ♀ pro-tarsal claws nearly as long as the 5th joint which is unusually short. ♀ ♀ always sulcate..... | <i>fasciventris</i> |
| Base and apex of pronotum evidently and more widely margined with yellow. Apical yellow margin usually not less than 23% of pronotal length, the basal margin usually more. Basal margin usually as well coloured as the apical..... | 4 |
| 4. Pronotum unusually widely margined throughout with yellow. The median black pronotal band reduced to about the same width as the yellow margins. ♂ tarsal claws unusually short about $\frac{3}{7}$ the length of the 5th joint (Southern: Mexico, Texas)..... | <i>habilis</i> |
| Pronotum moderately margined throughout with yellow. Protarsal claws of both sexes unusually long, longer than the 5th joint. ♀ ♀ apparently always sulcate..... | <i>hatchi</i> |

There is little likelihood of *hatchi* being confused with *verticalis*, *hybridus* or *habilis*.

From *cordieri* (*sublimbatus* Lec.) with which it is usually identified, its size will at once differentiate it. In addition, however, *cordieri* has less punctured elytra, its coxal processes are less broadly rounded its fore tarsal claws shorter, and its fore tarsal adhesive pads different.

The tiny disks in *cordieri* are plainly divided into three groups by transverse smooth lines. In *hatchi* these lines do not appear.

Fasciventris is even nearer *hatchi*. The fore-tarsal claws in *fasciventris* ♂ are scarcely $\frac{4}{5}$ the length of the 5th tarsal joint, but in the ♀ they are nearly as long as the 5th joint which, however, is unusually short.

In *hatchi* the fore tarsal claws both in the ♂ and ♀ are evidently longer than the 5th joint.

In *hatchi* ♂ the elytra are clearly more punctured especially basally than in the ♂ of *fasciventris*.

The ♂ genitalia are somewhat different, the tip of the aedeagus in *fasciventris* being more abruptly bent than in *hatchi*.

In both sexes of *fasciventris* the dark abdominal markings are usually clearly adherent to the border of the segments, while in *hatchi* the dark abdominal

markings usually form somewhat indefinite blotches evidently separated from the borders of the segments.

It gives me pleasure to name this interesting species after Professor Hatch who has done so much to enlarge our knowledge of the West Coast beetles.

The large series of *hatchi* before me is due to the kindness of Mr. Gordon Stace-Smith, Mr. Hugh B. Leech, who loaned me the whole of his extensive series, and to Professor M. H. Hatch who sent me over thirty specimens. In addition to these my own collection contains a number gathered over many years.

I shall send paratypes from my own series to that eminent Coleopterist, Mr. C. A. Frost, to the Canadian National Collection and to the British Museum.

Pairs of paratypes will be deposited in the Museum of Comparative Anatomy at Harvard and in the U.S. National Museum by Professor Hatch and in the American Museum of Natural History and the Philadelphia Academy of Science by Mr. Leech.

Reactions of Larvae of the Eastern Tent Caterpillar, *Malacosoma americanum* (F.), and of the Spotless Fall Webworm, *Hyphantria textor* Harr., to Pentatomid Predators

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During recent field studies of the behaviour and activity of larvae in colonies of *M. americanum* and *H. textor*, it was noticed that nymphs and adults of *Podisus placidus* (Uhler) and of *P. modestus* (Dallas) frequently visited colonies of the eastern tent caterpillar and occasionally those of the spotless fall webworm. Although small larvae, particularly those of the tent caterpillar, fell prey to both nymphs and adults, larvae of the fifth and sixth instars occasionally exhibited special reactions.

A bug which seized a larva on an *americanum* tent had difficulty in moving off with it and often the bug remained on the outer wall of the tent. Sometimes, this resulted in alarm reactions among the rest of the colony. In the subsequent milling, a few large larvae sometimes approached the predator and, in crawling over it, webbed it into the structure of the tent so tightly that it could not escape and eventually died.

A certain part of this spinning could be attributed to accidental entanglement while larvae were milling, but, in a few instances, there seemed to be something further involved. During one episode, a larva approached a bug from the front and kept so close that the bug could not raise its proboscis. The caterpillar butted continually with its head. While this occurred, two other larvae crawled back and forth over the bug from the two sides, laying a silk web. When the predator was webbed into the tent, the larvae moved away. Continued re-crossing of such a restricted area did not suggest completely accidental entanglement of the bug.

Webworm larvae of the last two instars were more direct in their reactions. During one episode, a larva encountered a bug on the lower, outside surface of the web. It grasped the bug by a leg with its mandibles, lifted it off the web, and, hanging head downward, whipped the forepart of its body to and fro. Thus, when the bug was finally released, it was thrown away from the web.

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